1. INTRODUCTION

The United States Office of Naval Research (ONR) together with Naval Facilities Engineering Services Center (NFESC) are currently in the early stages of establishing the feasibility for developing a very large Mobile Offshore Base (MOB).

The MOB is currently envisioned to be a 5,000 ft (approximately 1,500 m) long floating base, which is intended to serve as a forward supply point for military operations. The deck is long enough for landing of C-17 military transport planes. The unit includes very large volumes of storage space for prepositioned material and to serve as a major supply transfer point.

Currently, the MOB program is in the concept development stage with several contractors developing alternative concepts with the intent of proving feasibility and identifying issues requiring further development. Additionally, work is being done in the area of establishing standards and criteria, assessment of appropriate design tools and performance and operational availability issues.

In order to equitably evaluate or design alternate concepts on a consistent basis, or carry a single concept to final design, a detailed procedure for design is needed. Among others, this procedure must include:

- A description of the environment to which the MOB will be exposed during its lifetime, and
- the requirements and methodologies for performing the various analyses and design checks.

This document addresses only the former in any depth, although a short description of the way the statistical environmental data can be used in analysis is provided. The latter, design and analysis requirements and methodologies, is currently being examined by Bechtel National, Inc. (BNI) under a separate project (Delivery Order 23 of Contract No. N47408-93-D-7001, Design Tools and Methodologies).

The goal of the work, performed under Delivery Order 22, Environmental Specification, of Contract No. N47408-93-D-7001, reflected in this report, was to produce an Environmental Specification that will form part of an overall MOB classification process. It consisted of two parts:

1. Development of a Qualitative Environmental Specification
2. Development of a Quantitative Environmental Specification

The Qualitative Environmental Specification was first developed to primarily identify all the manifestations of the environment that could possibly be critical to the feasibility and design of the MOB. It is the more general part of the overall work and the one with the more theoretical background on environmental descriptors and various phenomena associated with winds, waves and currents.

The Quantitative Environmental Specification (Chapter 6 of this document) follows the Qualitative Environmental Specification and defines data for all aspects specific to the assumed MOB operating and transit locations.

1.1 Environmental Issues Related to Characteristics of the MOB

The primary issues that distinguish a MOB from a conventional floating structure, such as a semi-submersible platform (semi), relate to its size and use.

Semis are quite short relative to important wavelengths, so that variations of wind, waves and current across or along the platform are not important. However, with dimensions of the order of 5,000 ft, there may be significant variations over the length of the structure inducing responses not experienced by more uniform conditions.

For instance, non-uniform currents and wind will exert differential forces along the length of the MOB, resulting in connection forces or dynamic positioning requirements that are quite different from those found from more uniform conditions. Furthermore, a MOB may span 5 or 10 wavelengths, and so the variations of water particle motions from waves, across and/or along the vessel, will be very large. Accurate representations of these variations should be sought. It is not clear that linear irregular wave theory, usually used in the design of semis, provides adequate accuracy.

Other requirements are also rather different from those for a semi-submersible, and should be taken into account in assessing the environmental conditions. For instance, a MOB may develop torsional moments about the axis of the structure when oblique wave components are present, and these may be of importance in the design of connectors between modules, even when the associated waves are not extremely high. If this is the case, it will be important to include seastates in the design that include these conditions.

1.2 Reliability and Final Design Procedure

It is not possible to select one or more seastates for the design of a MOB, without knowing the particular characteristics and responses of the MOB structure itself. This is similar to the case of a tension leg platform as noted, for instance, in Section 2.5 of the American Petroleum Institute (API) Recommended Practice for Planning, Designing and Constructing of Tension Leg Platforms [API RP2T, 1987], where it states:

“Environmental criteria should be associated with a recurrence interval of the response of the structure. For example, the 100-year design event should be that which produces the worst platform response in 100 years. There may be different design events that give the worst response for different parts of the structure. It is also noted that the largest responses of TLPs are not necessarily produced by the highest wave conditions.”

The final design of the MOB will be based on rational probabilistic criteria, for instance, a return period of, say, 100 years. There are a number of important inter-related environmental components that affect the MOB, and it is not possible, nor rational, to choose design values of these without knowing the characteristics of the structure.

Therefore, this Specification provides the vehicle for determining *statistical or historical* information on the environment to which the MOB will be subjected, rather than *a set of discrete design seastates*. It will be the responsibility of the designer to use this information in a manner that assures that the responses of his/her particular structure have the appropriate reliability.

These environmental data can be used to determine the statistics of any structural response of interest. These response statistics can be used to check a number of MOB responses such as:

- the forces or stresses in the structure
- the fatigue damage (using, say, the Miner-Palmgren cumulative damage theory)
- the relative displacements of different modules (i.e., for aircraft operability)
- the slope of modules (i.e., for aircraft operability)
- the relative displacements of vessels and modules (for unloading operations)
- the proportion of time that the system is operable, etc.

Furthermore, since the data reflect sites around the world, they can be used for determination of responses either at deployment sites or during transit.

The statistical data, presented in a strictly statistical form, can thus be used for assessing any response, stress, displacement or fatigue.

The following are two ways that these data can be used:

1. Using a strictly probabilistic approach, the statistics of any response item (e.g. bending moment in a leg) can be found from the statistical or historical description of the environment provided here, and information on the response of the particular structure to a range of environments. The statistics of this response can then be compared with the design reliability criterion (e.g. return period must be greater than 100 years) to see whether the structure is both safe and economical.
2. A more easily implemented approach, from the point of view of the designer, is to determine a number of discrete seastates that give the appropriate level of reliability of some response. For instance, we might have a seastate that gives a 100-year return on the torsion, which is used to determine torsion loads on the connectors, as applicable. Another gives the 100-year bending moments about a horizontal transverse axis, and is used to find stresses associated with this condition. Another gives 100-year values for thruster power and is used to design the thrusters and associated equipment.

1.3 Organization of the Report

The introduction of Chapter 1 and outline of the objectives of this work (Chapter 2) are followed by a description of the MOB operational requirements as currently specified by the Navy (Chapter 3). Chapter 4 describes briefly, solely for the purpose of general information and completeness, the MOB concepts that are currently under development, and the expected general response of such structures to environmental conditions.

The principal chapters of the document are 5 and 6, the Qualitative Environmental Specification and the Quantitative Environmental Specification, respectively.

The Qualitative Environmental Specification is inherently descriptive and, to a certain extent, theoretical in nature, paving the way for deciding what types of environmental data and in what form are provided in the Quantitative Environmental Specification, as applicable to the MOB.

It starts with a general overview of atmospheric and ocean flows, which describe the processes by which winds, waves, currents and internal waves are created, and propagated. Then, the characteristics of each are in turn described, with particular reference to issues that are peculiar to the design and analysis of a MOB-type vessel. This is then followed by describing actual data that could be used by the MOB project, indicating who owns them, how they can be accessed, and their strengths and limitations. It concludes by addressing statistical issues related to environmental components and fatigue related issues.

The Quantitative Environmental Specification commences with an overview of the selected sites where data are actually provided for. Next, in Section 6.2, the data are described in some detail, providing information on where the data were obtained from, and their strengths and deficiencies. Section 6.3 gives a set of “recipes” telling the user how to go from the more general statistical data to develop detailed environmental conditions that can be used to estimate environmental forces on the MOB, and provides information on how to model certain environmental events not included in the raw data. Section 6.4 addresses the inherent uncertainty of particular environmental data, to aid the designer in the reliability analyses that are expected to be required in the design stage. The actual environmental data are summarized in Section 6.5.

Section 6.6 first gives an overview of the statistics at the various sites, followed by the description of the computer program MOBENV that allows the user to statistically “customize” and extract the data that have been assembled for the project.

Section 6.7, describes a study of a selection of Northwest Pacific hindcast typhoons to see how well the wind and wave fields fit simple models developed for the Gulf of Mexico, and summarizes the wind and wave fields in these typhoons. Finally, Section 6.8 outlines some recommendations for what may be valuable future development relating to the definition of the environment for MOB applications that are a product of either knowledge gained to date from this work and/or technology advancements or newly gathered data since the start of this project.

Chapters 7, 8, 9 and 10 contain a glossary of terms, a list of symbols (algebraic names and names used to represent variables in the data provided), abbreviations and references, resp.

A set of 9 appendices contain the CD ROMs with the environmental data, details of the contents of these tapes, the computer program MOBENV, and various supporting reports from the organizations providing the various hindcasts.

1.4 How to Effectively Use this Specification

This is a very large document containing a rather vast and varied amount of information. At first, it may seem as quite a task to digest all the provided information. It is indeed expected that, because of the, at times, highly specific technical nature of the subject, not all readers will be able to absorb in depth all of the information. Therefore, the following is an attempt to provide some, albeit simplistic, guidance as to how it might be best used depending on the specific need at hand or desired application.

The ultimate use of this work will be towards establishing the various critical environments for designing a MOB. The word “various” in the previous sentence is emphasized as the MOB, whether in its entirety as a vessel/structure or in the many components of which it will consist of, will be controlled by different sets of environment, in some cases very different. Such sets of design environmental conditions will be not only a function of the specific structure component of design interest but, also, will be directly a function of the response characteristics of a particular overall MOB configuration or concept. Even for similar in concept structures, say connected, it is very likely that a different set of environmental conditions will control each one.

As such, it is difficult to precisely define a “recipe” for blanket general use of this Specification. It should be first viewed as a collective attempt to assemble environmental information viewed critical to the MOB in light of its uniqueness, unprecedented size, operational requirements and global presence. A user solely interested in the general background of environmental effects, whether theoretical or observed, their definition, source and applicability to a MOB-like vessel will be satisfied by reading only through Chapter 5, the Qualitative Environmental Specification.

However, Chapter 6, the Quantitative Environmental Specification, should be the focus of those that will be involved in the actual design of a MOB. In that chapter, Section 6.7, the study on potential correlation between global typhoon descriptors and wave, wind and current effects provides an interesting attempt on examining potential relationships between storms in the Northwest Pacific and Gulf of Mexico. However, it is more of informational nature rather than direct application.

The user most interested in the actual core of the information (data) for use in the various aspects of design should focus on Sections 6.1 through 6.5 for all information related to the environmental data (hindcast, additional environmental effects and related uncertainties) as well as Appendices A through D and F through I. These parts of the Specification provide and explain all obtained raw data.

Perhaps, the most important part in terms of data application is the use of the computer program MOBENV (described in Section 6.6 and included in Appendix E). After digesting the information given in Sections 6.1 through 6.5, use of this program will provide not only ease in accessing the raw data but also the statistical analyses, as desired (joint probability density, as well as cumulative, marginal, conditional, extremal and directional distributions), to determine the appropriate set of design environmental conditions for the task at hand.